Surface Acoustic Wave Microscopy of Optics

Michael J. Quarry
(925) 422-2427
quarry1@llnl.gov

We investigated the feasibility of surface acoustic wave microscopy to detect fine cracking in NIF optics. Cracks occur in the surface of NIF optics from the grinding of the surface, and subsequent polishing still leaves fine cracks. An Olympus UH-3 acoustic microscope was refurbished to enable surface acoustic wave microscopy from 200 MHz to 1 GHz on fused silica. The system uses high-frequency bulk and surface acoustic waves to characterize surfaces, near surfaces, and thin films. Feasibility studies were performed on polished fused silica.

Project Goals

The goal of the project is to show detection of fine cracking (1 to 15 µm) in the surface of a polished sample of fused silica over a 2-mm-x-2-mm area.

Relevance to LLNL Mission

Surface acoustic wave microscopy will enable the acoustic characterization of NIF optics without etching. Characterization of laser damage for mitigation purposes may also now be investigated. Mapping density gradients in JASPER projectiles is another possible LLNL application. Other applications include thin films, grain structure visualization, and observation of biological cells without staining.

FY2006 Accomplishments and Results

An Olympus UH-3 surface acoustic wave microscope was refurbished for operation. Two-hundred-MHz and 400-MHz acoustic lenses were found to be operational, while the 1-GHz lens was damaged. However, we have access to a 1-GHz lens through our relationship

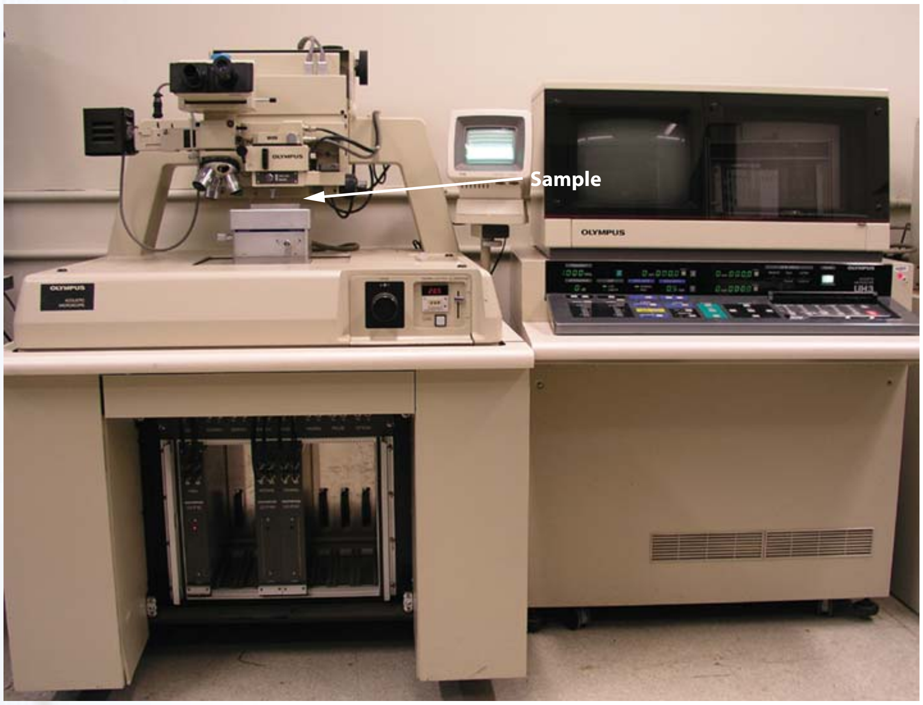

Figure 1. Olympus UH-3 acoustic microscope system.

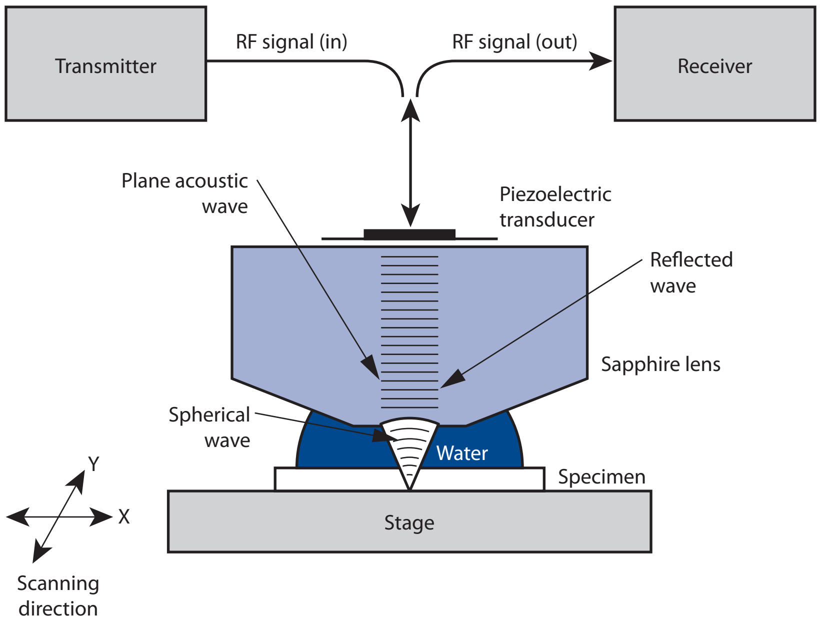

Figure 2. Diagram of the ZnO transducer and sapphire lens.

with Pennsylvania State University. At 1 GHz the lateral resolution of the system is 1 μm. The acoustic lens is designed with an F-number of 0.7 to optimize surface and near surface resolution.

Figure 1 shows a picture of the system. A sample is placed on the stage, and an acoustic lens is raster-scanned over the sample to obtain an image. A diagram of the transducer and lens is shown in Fig. 2. The transducer is driven by tens of cycles of a tone-burst generator. The burst travels down a sapphire buffer rod and is focused through the lens at or near the surface of the sample. A Rayleigh surface wave and the bulk waves interfere with each other. A peak detector captures the peak of the reflected energy. The scanning process takes about 10 s to form an image.

A fused silica Corning 7980 sample (Fig. 3) with grinding and polishing fractures was examined with the Olympus system. An area of 1 mm^2 was scanned in the position indicated in Fig. 3. The resultant image (Fig. 4a) shows many fine cracks. A zoomed-in image with an area of 0.25 mm^2 is also shown, in Fig. 4b. The crack lengths along the surface are about 10 μm using the scale on the image to measure across the crack. A similar image could be obtained without etching.

In the future, we will look at other applications for surface acoustic wave microscopy. One important problem is looking at gradient density structures including JASPER projectiles. We can also improve the technology with new lens and transducer designs. PZT is a much more efficient transduction material than the current ZnO. Frequency could be optimized with a tunable tone-burst generator.

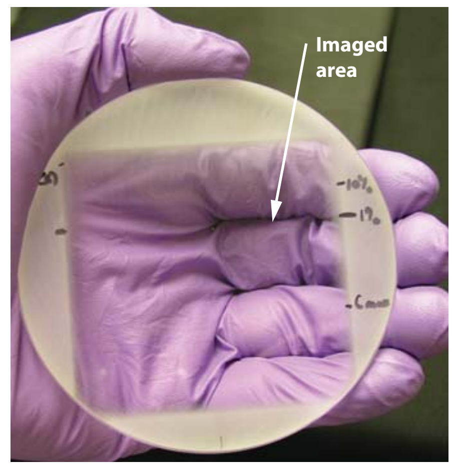

Figure 3. Polished fused silica sample. The area investigated with surface acoustic wave microscopy is indicated by the arrow.

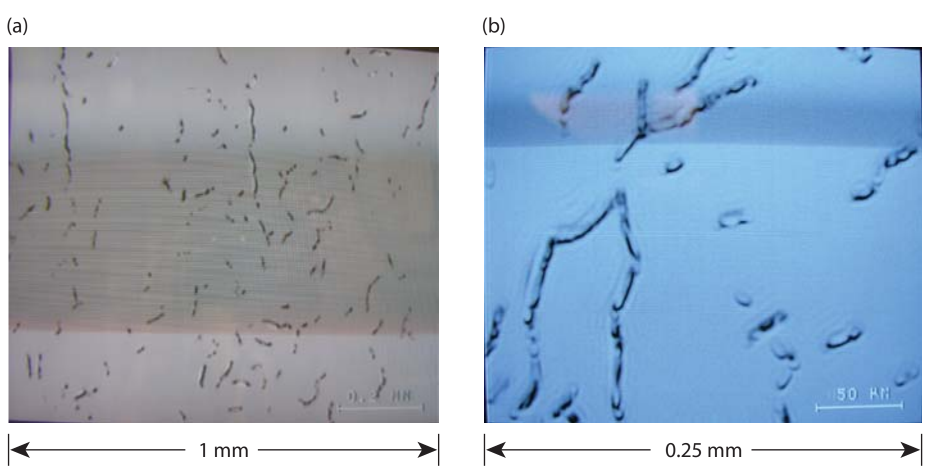

Figure 4. (a) Image of the surface of polished fused silica, showing surface fractures with a crack length of about 10 μm as measured using the scale on the image. (b) Enlargement of the same approximate area shown in Fig. 3.